Section 643
Issue No. 2
September 1969

UNDERGROUND CONDUIT AND MANHOLE DESIGN AND CONSTRUCTION

CONTENTS

1. GENERAL

1.1 This section is intended to provide REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in the design and construction of REA borrower's telephone systems. It discusses in particular the design and construction of manhole and underground conduit systems.

1.2 Underground conduit and manhole construction for REA borrowers usually will be by contract from plans prepared by a consulting engineer. The plans will detail the type(s) of manholes with associated hardware and type(s) of conduit with conduit configurations, as well as the location of the manholes and the routing of the proposed conduit system. The construction plans and specifications should also show the grades or level of the conduit as required and the location of subsurface structures that will be encountered. The Contractor will supply the labor and material necessary to build the manhole and conduit system in accordance with the engineer's plans.

1.3 It is customary to provide more ducts than initially needed because of the greater expense of reopening the trench and adding ducts to the existing conduit structure.

1.4 The Engineer should become familiar with federal, state and municipal regulations, ordinances, and franchises relating to underground structures.

1.5 The Engineer should consider the economic feasibility of placing plastic flexible conduit in conjunction with buried cable where it is anticipated that future roads, streets, subdivisions, shopping centers, etc., may be constructed in the near future. It may also be considered for those areas where there are numerous underground facilities and in new housing developments where an unpredictable amount of upgrading may be required in the future. This conduit plant would facilitate the installation of reinforcement cable in the future.

2. UNDERGROUND CONDUIT AND MANHOLE APPLICATIONS

2.1 Underground conduit and manholes should be considered for the following conditions:

2.11 Where public authorities will not permit aerial construction, where direct burial plant is inadvisable and where alternate aerial or buried routes are not practicable.

2.12 Where the appearance of an aerial entrance cable to a central office building would be objectionable and where buried cable would not be practicable due to anticipated subscriber growth.

2.13 For crossing parkways or limited-access highways where highway authorities prohibit aerial crossings.

3. TYPES OF CONDUIT AND USE

3.1 Various types of conduit are available and suitable for installation, but specific application in reference to comparative economics of costs and environmental conditions should be evaluated by the Engineer. Costs would encompass the actual cost of the conduit plus cost of shipment from the closest supplier, breakage or damage, and installation costs relative to the manpower skills required.

3.2 The types of conduit most frequently considered are:

3.21 Multi-Duct Clay Conduit - Available in bore sizes of 3 1/4", 3 1/2", and 4". Dowel pins are required for joining and aligning individual sections, and the jointing requires wrapping with mortar bandage, tape and mortar, etc. Mitered duct is required to form curved sections.

3.22 Multi-Duct Concrete Conduit - Available in bore sizes of 3 1/2" and 4 1/2". Basically two types are available, one with bell and spigot design with joint seals utilizing rubber gaskets and/or joint sealing compound, and the other type utilizes a polyethylene sleeve with dowel pins for alignment. In both types, short joints, miters, split conduit and special adapters, such as concrete to steel, concrete to concrete, and concrete to plastic are standard manufactured materials.

3.23 Asbestos-Cement Conduit (ACD) - Available in inside diameters of 2", 3", 3 1/2", and 4" and available in two types: ACD Type I (thin wall) for installation with concrete encasement and ACD Type II for installation in earth without concrete encasement. Plastic couplings with sealing compound are used for jointing. Conduit bends, sweeps, curved segments, adapters, etc., are manufactured standard items. Spacers, both plastic and/or concrete, are available for building conduit formations with from 1" to 3" separations. The conduit can readily be cut at the job site using a coarse-tooth hack saw, a six point rip-saw or a pipe cutter. Tapering is required if the conduit is cut.

3.24 Fiber Conduit - Fiber conduit is a formation of fiber pulp impregnated with hard coal tar pitch. Available in inside diameters of 2", 3", 3 1/2", 4" and in two types: Type I (thin wall) for use with concrete encasement and Type II for installation in earth without concrete encasement. Plastic couplings are used for jointing. Conduit bends, sweeps, bell ends, adapters, reducers, plugs and caps, etc., are manufactured standard items. Spacers, both plastic and concrete, are available for building conduit formations with from 1" to 3" separations. This conduit can be cut on the job with an ordinary coarse tooth hand saw. Tapering is required if conduit is cut.

3.25 Plastic Conduit - Available in inside diameters of 2", 3", 3 1/2", and 4" and in two types: Type I (thin wall) for concrete encasement and Type II for direct earth installation. Its semiflexibility permits gradual changing of the width and height of a duct bank without the use of special miter fittings. This type conduit has a low coefficient of friction so that longer conduit runs can be considered. Refer to Paragraphs 6.2 and 6.3 for application considerations. Jointing is accomplished with a plastic coupling and solvent cement. Sweeps, adapters, plugs, bell ends, etc., are standard items of stock. Plastic conduit can be cut with a hack saw. Plastic spacers are available for building conduit formations.

3.26 Plastic Flexible Conduit - Available in inside diameters of 2" and in 500 foot lengths (coils). Watertight jointing is made by heat fusion with caps, ells, etc., available as standard items. There are basically two types of flexible conduit: One has both inside and outside walls of smooth finish. This conduit can be installed either by trenching and/or plowing. The conduit is relatively flexible and may be bent in a radius as sharp as four feet without kinking. Special fittings are not usually necessary to make turns, dips, and bends. Where other service

lines or pipes are encountered, long lengths of the conduit may be fed under the other underground utility lines or pipes and pulled through, thereby eliminating the need for splicing the conduit. Since the outer jacket of cables to be installed in the conduit is polyethylene, the coefficient of friction between the cable and the conduit is substantially reduced and longer pulls may be made depending on the size of cable to be installed and the number of bends in the conduit run. Successful cable pulls up to 2,000 feet have been made through this conduit with cables up to an inch in diameter. It is not unreasonable to expect that manholes or pull boxes can be spaced at intervals in excess of 1,000 feet when cables having outside diameters of 1.6 inches are to be installed. This conduit can be installed in multiple configurations. It may also be placed in a very narrow trench and where a 2" ID is adequate, this conduit is probably the most economical type to use. The other type of flexible conduit is molded with a corrugated wall but limited to subsidiary conduit routes only. This corrugated conduit must be placed on a horizontal plane only (side by side).

3.27 Steel Pipe - Steel pipe is intended for use for conduit runs only in special conditions whereby conduit materials described in the preceding paragraphs of this section would not be practicable. Such conditions might include locations where trenching could not be done and the conduit must be placed by means of a pipe pusher. Steel pipe is available in all commercial sizes and can be obtained with threaded ends and couplings or with plain ends.

3.28 Sewer Tile - Sewer tile is available in all commercial sizes and is used primarily for manhole drains or sumps.

3.29 Cast Iron Bend - Cast iron 90° bends are available with inside diameters of 2", 3", and 3 1/2" and with radii of 24" and 30". Cast iron bends are used for extension of the subsidiary conduit for termination on poles or buildings. Concrete encasement is not required with this installation. Pipe caps and couplings are standard manufactured items.

4. MANHOLE TYPES AND USE

4.01 All manholes shall be designed and constructed so as to provide sufficient and suitable space for the cables and associated equipment to be installed therein. The type and size of manholes reasonably anticipated in the REA program are shown diagrammatically in the following Figures 1 through 7.

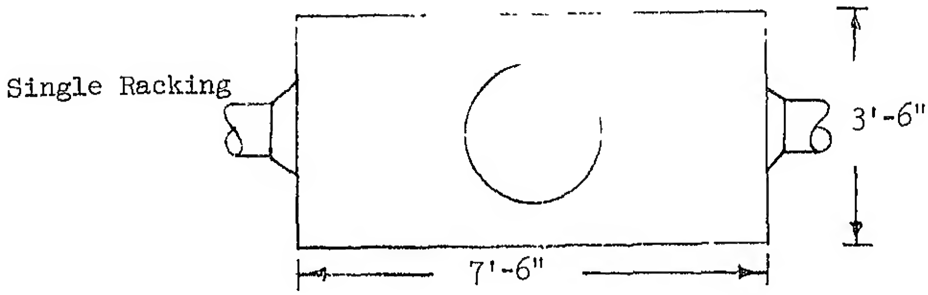


FIGURE 1

Manhole Type UM-A

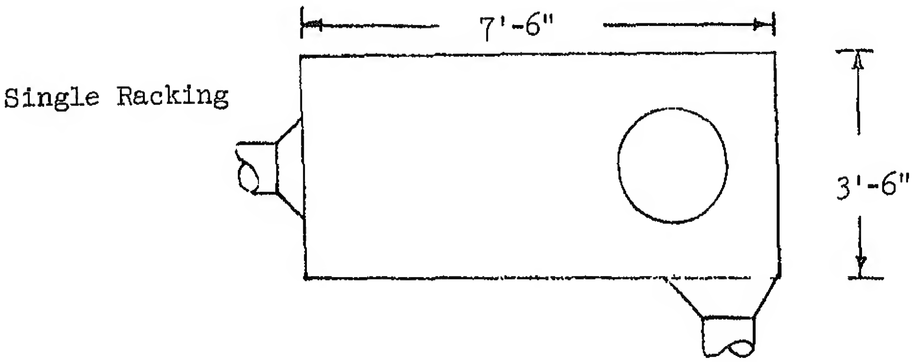


FIGURE 2

Manhole Type UM-L

Note: Dimensions reflect minimum inside dimensions of the manholes.

Single Racking

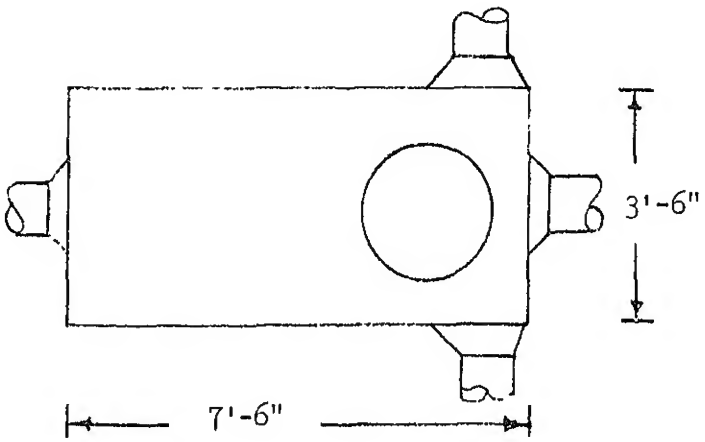


FIGURE 3

Manhole Type UM-J

Single Racking

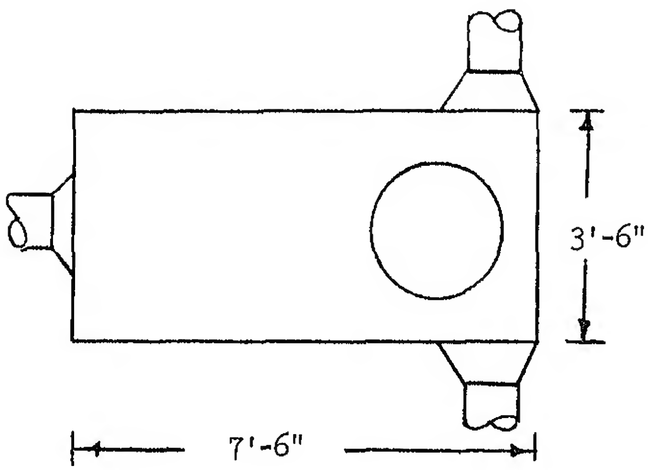


Figure 4

Manhole Type UM-T

Note: Dimensions reflect minimum inside dimensions of manholes.

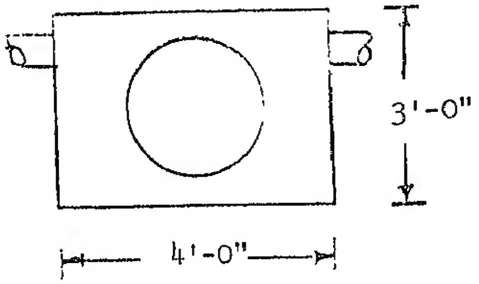


FIGURE 5

Manhole Type UM-X

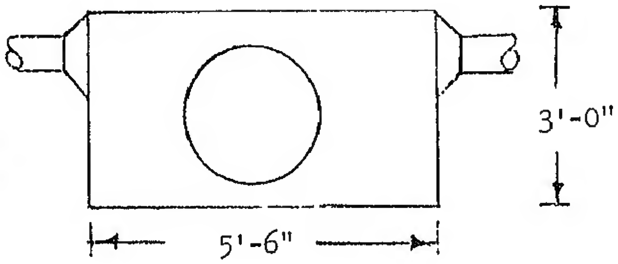
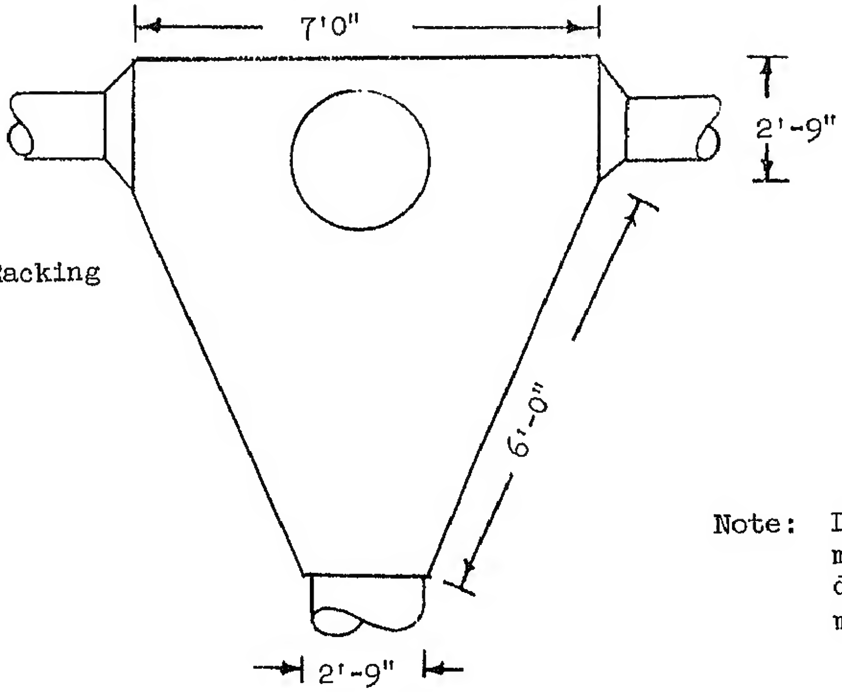


FIGURE 6
Manhole Type UM-Y



Note: Dimensions refl
minimum inside
dimensions of
manholes.

FIGURE 7

Manhole Type UM-V

4.02 Headroom - The headroom required in each manhole will be shown on the detailed drawings. In general, the headroom must be sufficient to provide suitable racking space for each cable to be placed plus a clear space of 12 inches just above the floor and also just below the roof of the manhole. The cables will be racked on 6-inch centers vertically. The <u>minimum</u> headroom to be provided for the various manhole types is as follows:

Type UM-X	3'-6"
Type UM-Y	4'-0"
Type UM-A	5'-6"
Type UM-L	5'-6"
Type UM-T	5'-6"
Type UM-V	5'-6"
Type UM-J	5'-6"

4.03 Design of Manhole Floors

4.031 In firm soil, it is suggested that unreinforced concrete be used for the floor. For manholes with unreinforced concrete walls, the floor should be 4 inches thick and for a manhole with reinforced walls the floor should be 6 inches thick.

4.032 In fluid soils reinforced concrete is required for the manhole floor. Table 1 and Figures 8 and 9 reflect the design considerations for reinforcing and thickness of manhole floors in fluid soils. For rectangular manholes having a depth of the finished floor of not more than 16 feet below the surface, the floor shall be 6 inches thick and shall be reinforced with 5/8-inch round deformed bars spaced 8 inches on centers.

TABLE 1

Manhole Floor Design Requirements for Floor Thickness and Reinforcement in Fluid Soil for Type UM-V Manholes

Depth of Manhole Floor below Grade (feet)	Thickness of Floor (inches) Minimum	Spacing of Reinforcement (See Figure 8) Spacing A (inches)	Spacing B (inches)	Spacing C (inches)
8	6	8	9	11
9	6	8	9	11
10	6	8	9	11
11	6	8	9	11
12	6	8	9	11
13	6	8	9	11
14	6½	7	8	10
15	7	6½	8	10
16	7	6½	8	10

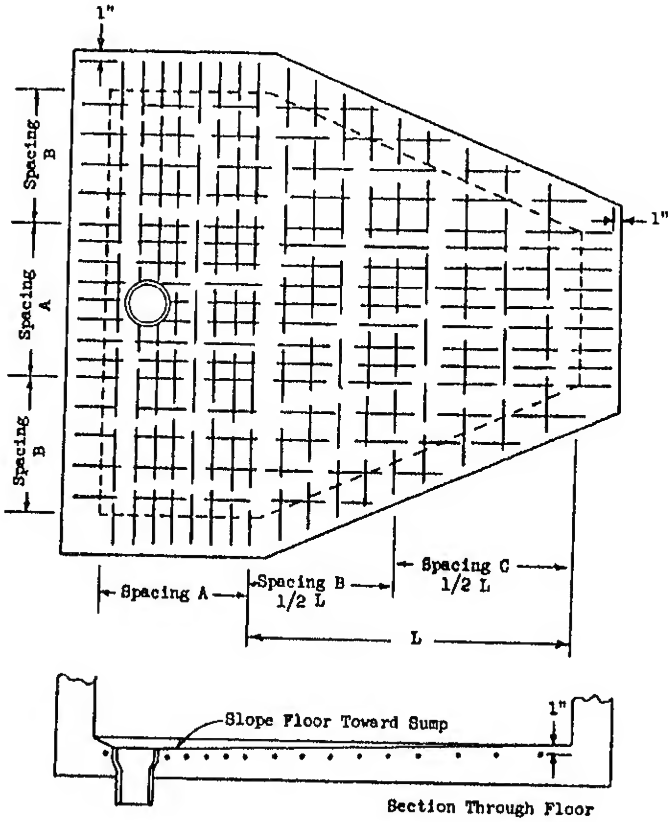


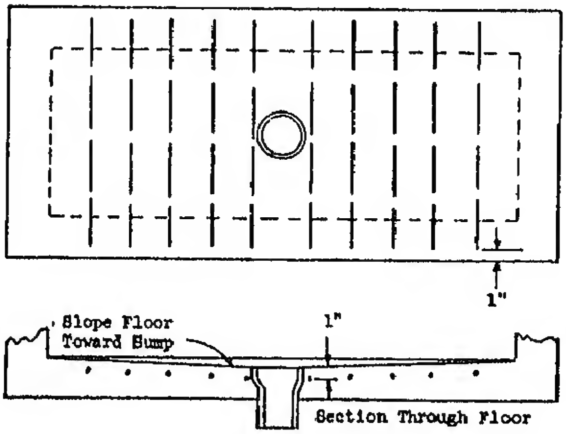
FIGURE 8

Design Floor Details For Type UM-V Manholes
To Be Constructed in Fluid Soils

See Table 1 for thickness of floor and spacing of reinforcement.

FIGURE 9

Design Floor Details for Rectangular Manholes
To Be Constructed in Fluid Soils

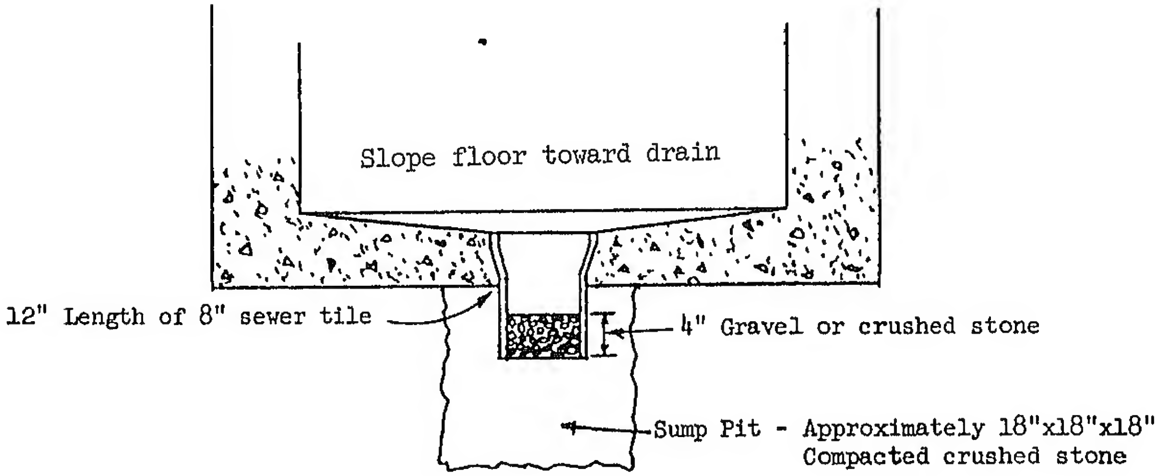


4.04 Sump or Drain - A sump or drain shall be located directly under the manhole cover and at a depth such that the finished surface of the floor may be graded toward the sump or drain. The sump or drain will be at least 8 inches in diameter or 8 inches square. A satisfactory sump or drain can be made with a 12-inch length of 8-inch sewer tile. Figure 10 indicates two types of design considerations.

FIGURE 10

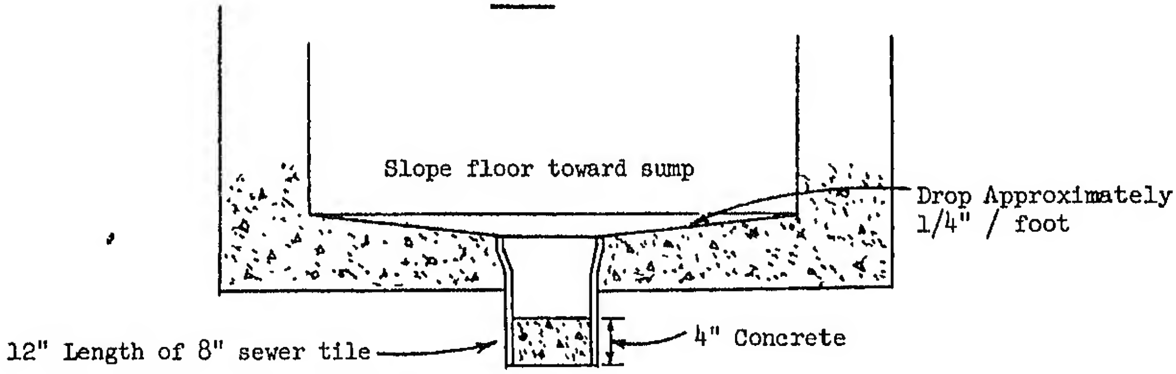
Design for Manhole Sump or Drain

Sump - Drain



For use when floor is above water level

Sump



For use when floor is below water level

4.05 Design of Manhole Walls - Table 2 shows the wall thickness and reinforcement required, if any, for concrete walls of manholes to be constructed in firm soil or fluid soil. It will be noted in this table that the variations in thickness of concrete walls and the amount of vertical reinforcement required varies only with the depth of the manhole walls. The vertical reinforcing bars should be of a length sufficient to extend one inch from the bottom of the concrete floor to within one inch of the top of the manhole roof. In addition to the vertical reinforcement given in Table 2, it will be necessary to provide some horizontal reinforcement. For walls up to 12 inches thick, the horizontal reinforcement shall consist of round bars 3/8-inch in diameter or larger spaced 12 inches on center. For walls more than 12 inches thick, the horizontal reinforcement shall consist of round bars 5/8-inch diameter or larger spaced 12 inches on centers. The horizontal reinforcing bars should be of a length sufficient to extend to within one inch of the outside surfaces of the two adjacent walls.

FIGURE 11

Typical Manhole Wall Reinforcing Design

See Table 2

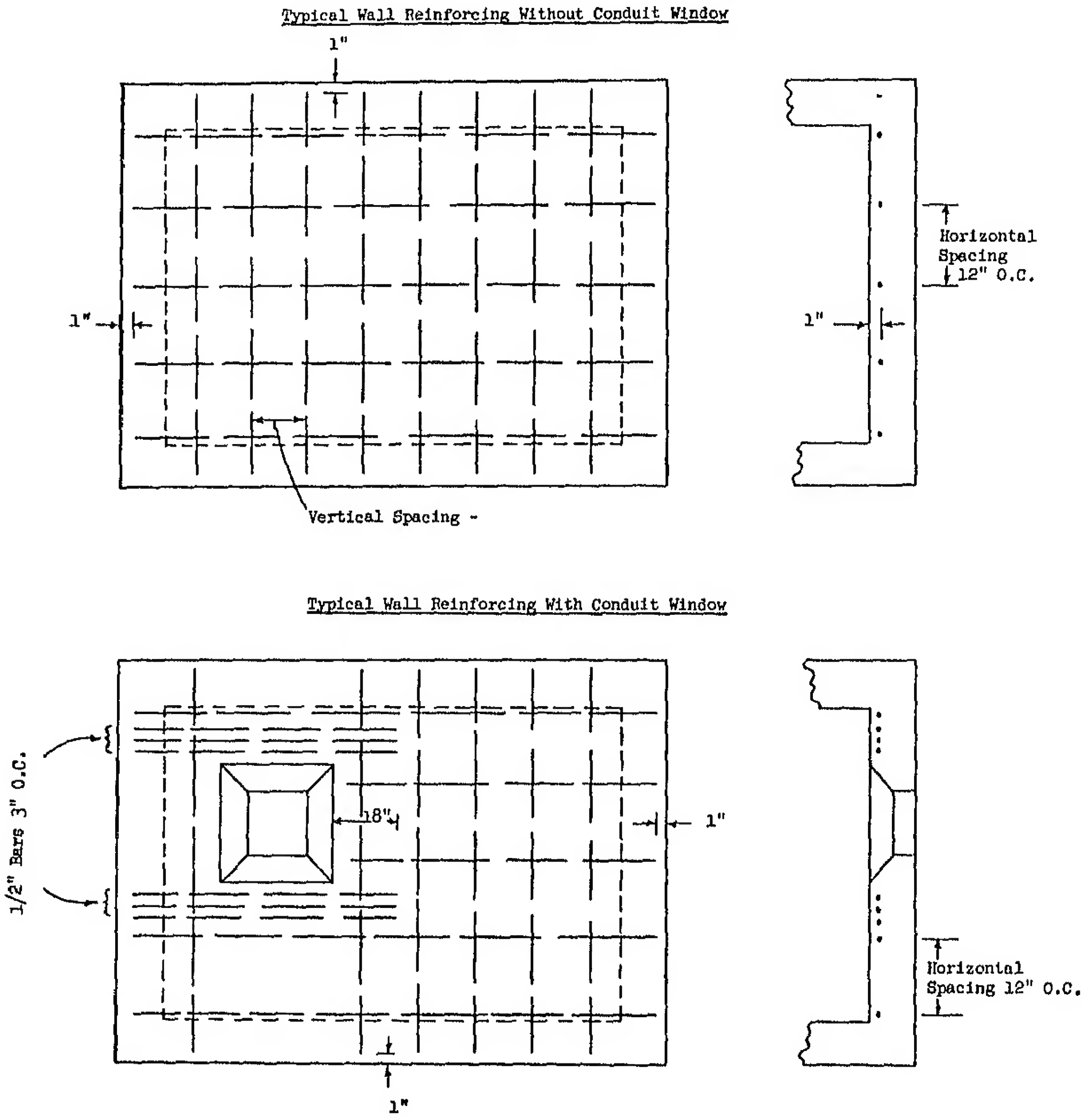


TABLE 2

CONSTRUCTION OF MANHOLE WALLS

	Depth of Manhole Floor Below Surface of Street	Plain Walls	Reinforced Walls		
		Thickness of Walls (Inches)	Thickness of Walls (Inches)	Vertical Reinforcement Using Deformed Bars	
				Size	Spacing
FIRM SOIL	8 ft. 0 in. or less	6	6	none	none
	8 ft. 6 in.	7	6	3/8 in. Round 1/2 in. Round	8 in. O.C. 12 in. O.C.
	9 ft. 0 in.	7 1/2	6	3/8 in. Round 1/2 in. Round	6 in. O.C. 10 in. O.C.
	9 ft. 6 in.	8	6	3/8 in. Round 1/2 in. Round	5 1/2 in. O.C. 9 in. O.C.
	10 ft. 0 in.	8 1/2	6	3/8 in. Round 1/2 in. Round	4 in. O.C. 6 in. O.C.
	10 ft. 6 in.	9	6	3/8 in. Round 1/2 in. Round	4 in. O.C. 7 in. O.C.
	11 ft. 0 in.	10	6	1/2 in. Round	6 in. O.C.
	11 ft. 6 in.	10 1/2	6	1/2 in. Round	5 in. O.C.
	12 ft. 0 in.	11	6 1/2	1/2 in. Round	5 in. O.C.
	12 ft. 6 in.	12	6 1/2	1/2 in. Round 5/8 in. Round	4 1/2 in. O.C. 7 in. O.C.
	13 ft. 0 in.	12 1/2	7	1/2 in. Round 5/8 in. Round	4 1/2 in. O.C. 7 in. O.C.
	13 ft. 6 in.	13	7	5/8 in. Round	6 1/2 in. O.C.
	14 ft. 0 in.	14	7 1/2	5/8 in. Round	6 1/2 in. O.C.
	14 ft. 6 in.	14 1/2	7 1/2	5/8 in. Round 3/4 in. Round	5 1/2 in. O.C. 8 in. O.C.
	15 ft. 0 in.	15	8	5/8 in. Round 3/4 in. Round	5 1/2 in. O.C. 8 in. O.C.
	16 ft. 0 in.	REINFORCEMENT REQUIRED	9	5/8 in. Round 3/4 in. Round	5 1/2 in. O.C. 7 1/2 in. O.C.
	17 ft. 0 in.		9 1/2	5/8 in. Round 3/4 in. Round	4 1/2 in. O.C. 7 in. O.C.
	18 ft. 0 in.		10	5/8 in. Round 3/4 in. Round	4 in. O.C. 6 in. O.C.
	19 ft. 0 in.		11	5/8 in. Round 3/4 in. Round	4 in. O.C. 5 1/2 in. O.C.
	20 ft. 0 in.		11 1/2	5/8 in. Round 3/4 in. Round	3 1/2 in. O.C. 5 1/2 in. O.C.
FLUID SOIL	8 ft. 0 in. or less	9	6	1/2 in. Round	6 in. O.C.
	8 ft. 6 in.	10	6 1/2	1/2 in. Round	6 in. O.C.
	9 ft. 0 in.	11	7	1/2 in. Round	5 1/2 in. O.C.
	9 ft. 6 in.	12	7 1/2	1/2 in. Round	5 in. O.C.
	10 ft. 0 in.	13	8	1/2 in. Round	4 1/2 in. O.C.
	10 ft. 6 in.	14	8 1/2	1/2 in. Round	4 in. O.C.
	11 ft. 0 in.	15	9	5/8 in. Round	6 in. O.C.
	11 ft. 6 in.	16	9 1/2	5/8 in. Round	5 1/2 in. O.C.
	12 ft. 0 in.	REINFORCEMENT REQUIRED	10	5/8 in. Round	5 1/2 in. O.C.
	12 ft. 6 in.		10 1/2	5/8 in. Round	5 in. O.C.
	13 ft. 0 in.		11	5/8 in. Round 3/4 in. Round	4 1/2 in. O.C. 6 in. O.C.
	13 ft. 6 in.		11 1/2	5/8 in. Round 3/4 in. Round	4 in. O.C. 6 1/2 in. O.C.
	14 ft. 0 in.		12	3/4 in. Round	5 1/2 in. O.C.
	14 ft. 6 in.		12 1/2	3/4 in. Round	5 1/2 in. O.C.
	15 ft. 0 in.		13	3/4 in. Round	5 in. O.C.
	16 ft. 0 in.		14	3/4 in. Round	4 1/2 in. O.C.

4.06 Design of Manhole Roofs - The designs of reinforced concrete roofs is reflected in the following Tables 3 and 4 and Figures 12 and 13 for both rectangular and Type UM-V manholes.

TABLE 3

Roof Thickness and Reinforcement
For All Rectangular Manholes

Inside Width of Manhole	Roof Thickness
3'-0"	6"
3'-6"	6"
4'-0"	7"
4'-6"	7½"

Reinforcement consists of 1/2-inch round deformed bars.

TABLE 4

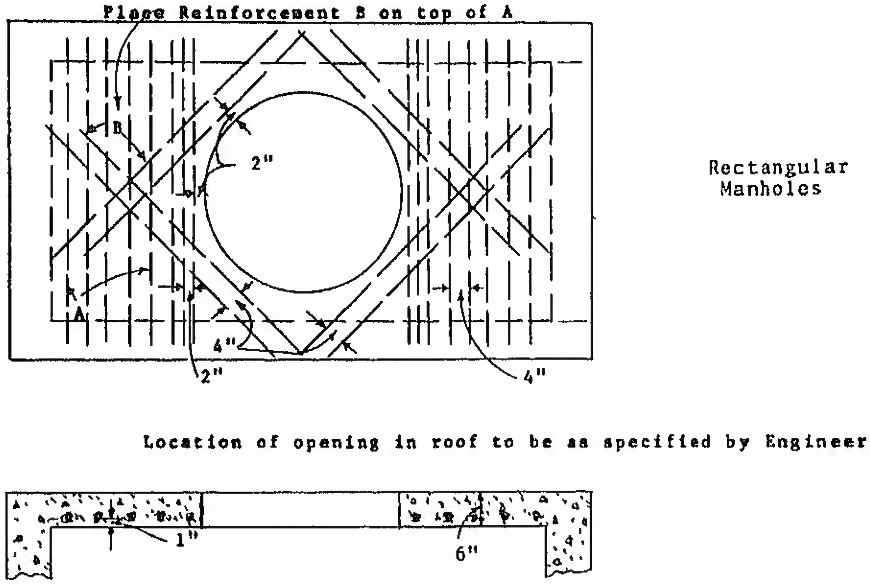
Roof Thickness and Reinforcement
For UM-V Manhole

Inside Width or Length Whichever is Greater	Thickness of Roof (inches)	Spacing B and C (inches)
8'-0"	11	5½
9'-0"	11½	5½
10'-0"	12	5
11'-0"	12½	5
12'-0"	13	4½

Reinforcement consists of 3/4-inch round deformed bars. For fractional distances use next greater thickness.

FIGURE 12

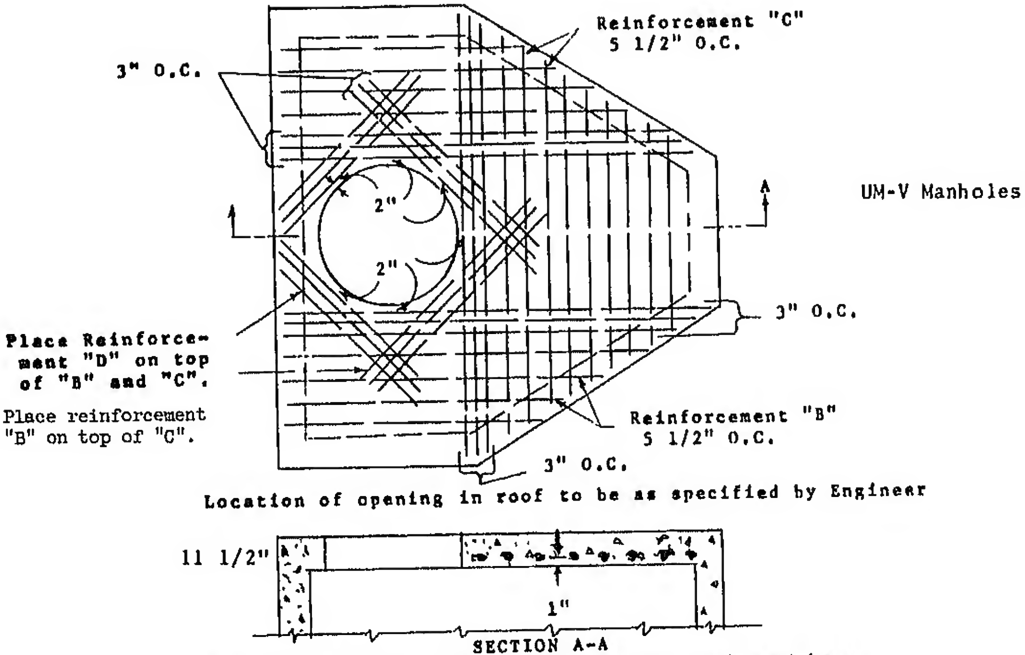
Roof Design for Rectangular Manholes



Reinforcement to consist of 1/2" round deformed bars

FIGURE 13

Roof Design for UM-V Manholes



Reinforcement to consist of 3/4" round deformed bars

4.07 Manhole Openings - The manhole opening size is determined by the type and size of the manhole frame. The diameter of the opening at the base of the frame should approximate the diameter of the opening in the manhole roof. Table No. 5 presents the proper size of manhole opening form to be used with the manhole frame of the indicated size and type.

TABLE 5

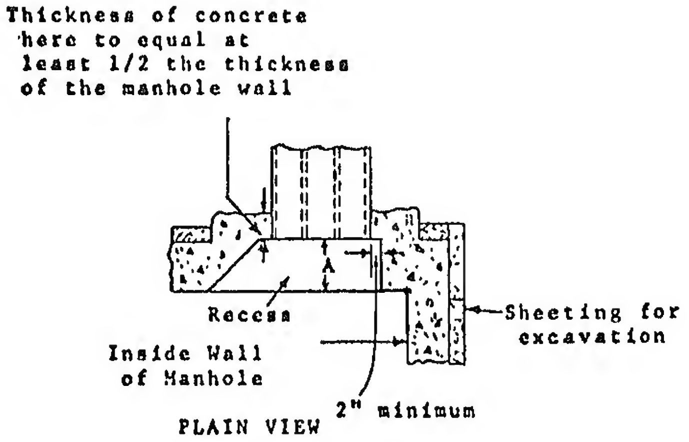
Manhole Opening Form for Size and Type of Manhole Frame

Type	Manhole Frame Size (inches)	Manhole Opening Form Size (inches)
B	24	34
B	27	38
B	30	41
SB	27	34
SB	30	38
R	27	28
R	30	31

4.08 Manhole Wall Recesses - It is necessary when recesses are constructed at conduit entrances, that sufficient concrete is placed between the face of the recess and the wall of the excavation to provide a watertight bond. The concrete thickness should equal at least one half the manhole wall thickness. If conduits are splayed as they enter the manhole, recessing of the duct bank is normally not required. Additional information is noted on Figure 14.

FIGURE 14

Conduit Entrance Recess



A = 6" for conduit entrances in UM-V manholes, 8" for main conduit entrances on side walls of rectangular manholes and 3" for other main conduit entrances.

NOTE: When recesses are desired for future duct the Engineer should specify the size and location of such recesses.

4.09 Cable Racks and Cable Rack Supports - At the time the manhole is constructed, inserts should be placed in the walls for attachment of the ultimate number of cable racks or cable rack supports which will be needed in the manhole. Spacing of cable racks should be as follows for manhole sizes as shown in Figures 1 - 7. For manholes of different sizes the Engineer should indicate on the construction drawings the rack spacings.

4.091 Type UM-A, two racks spaced 30 inches from the end walls will provide a 30-inch separation between cable racks for the splicing bay.

4.092 Type UM-L, UM-T and UM-J, two racks spaced 30 inches from the end walls provides a 30-inch separation between racks for the splicing bay.

4.093 Type UM-V, on the two side walls, two racks spaced 24 inches from the small end wall. Thence, 30 inches from the first rack will provide a 30-inch separation between racks for the splicing bay. Two racks placed on the end wall 27 inches from the two side walls will provide a 30-inch separation between racks for the splicing bay.

4.094 Type UM-X, one cable rack spaced equidistant from the two end walls.

4.095 Type UM-Y, two cable racks spaced 18 inches from the two end walls provides a 30-inch separation between cable racks for splicing.

4.096 The number of vertical cable racks as determined by the headroom of the manhole is indicated in Table 6 below, and typical installations are shown on Figures 15 and 16.

TABLE 6

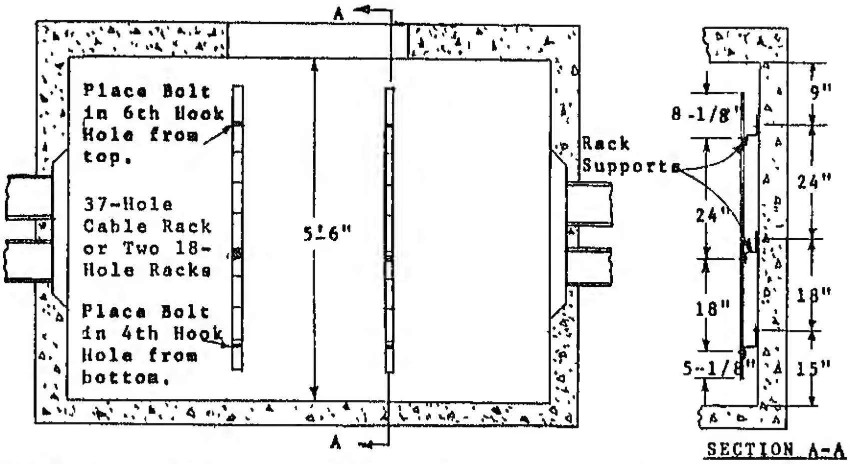
Number of Racks Per Vertical Strip of Racks

Headroom	Number of Racks		
	14 Hole Racks	18 Hole Racks	37 Hole Racks
5'-0"	1	1 or	1
5'-6"		2 or	1
6'-0"		2 or	1
6'-6"	3		
7'-0"	2	1	
7'-6"	1	2	
8'-0"		3	
8'-6"	4		
9'-0"	3	1	
9'-6"	2	2	
10'-0"	1	3	
10'-6"			
11'-0"	4	1	

Size of Rack	Distance Between Mounting Bolt Holes
8 Hook Holes*	13 1/2 inches
14 Hook Holes	22 1/2 inches
18 Hook Holes	28 1/2 inches
37 Hook Holes	Not equipped with bolt holes

* The 8 hole rack is normally used in side wall space above or below existing racks or in end walls for placing cable stubs or subsidiary cables.

Typical Cable Rack Installation



Notes: 1. Changes in locations of cable racks, additional racks, or different type cable racks will be specified by the Engineer when required.

2. Before mounting cable rack supports on wall, chip away any projections on the wall which might prevent even bearing of the support against the wall.

FIGURE 15

Typical Cable Rack

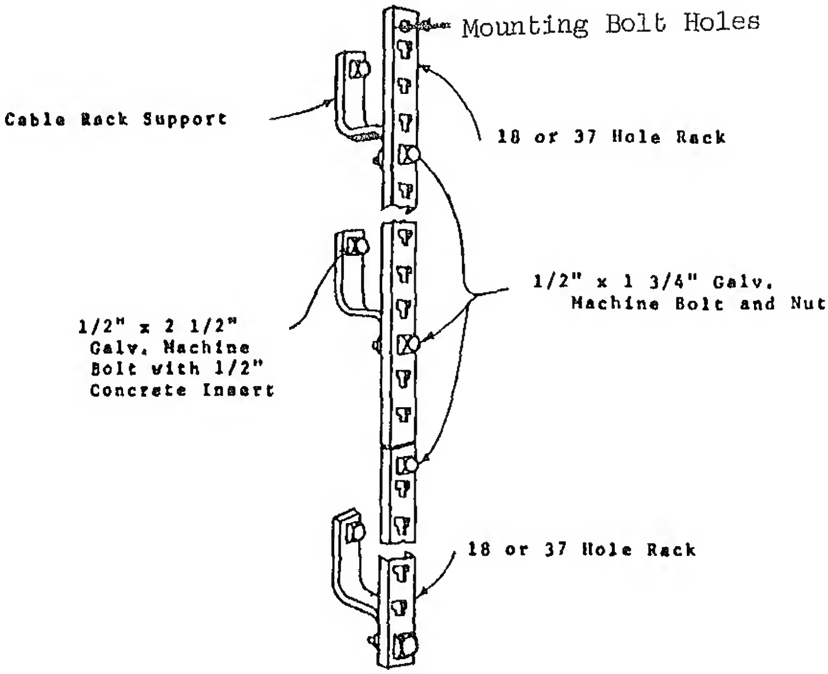


FIGURE 16

4.10 Pulling-In Irons - One pulling-in iron is required to be placed in the wall opposite each duct entrance at a point from six to twelve inches below the ducts with which they are associated and in line with the center line of the duct or bank of the ducts. With a six inch concrete wall, the vertical legs of the iron should bear against the outside face of the wall. For heavier walls, the legs should be embedded in the concrete of the wall as indicated in Figure 18.

Typical Arrangement of Pulling-In Irons

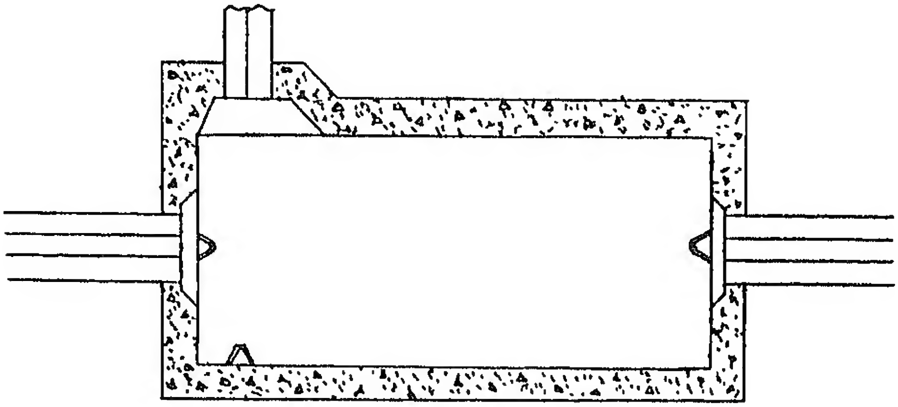


FIGURE 17

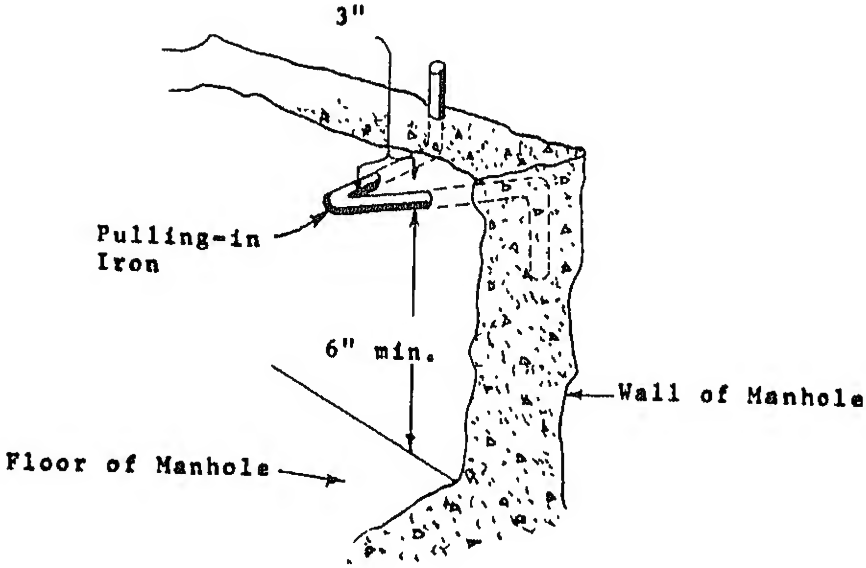


FIGURE 18

4.11 Frames and Covers - The following types of manhole frames and covers are available as standard manufactured items and should be considered for usage.

Type B Frame and Cover

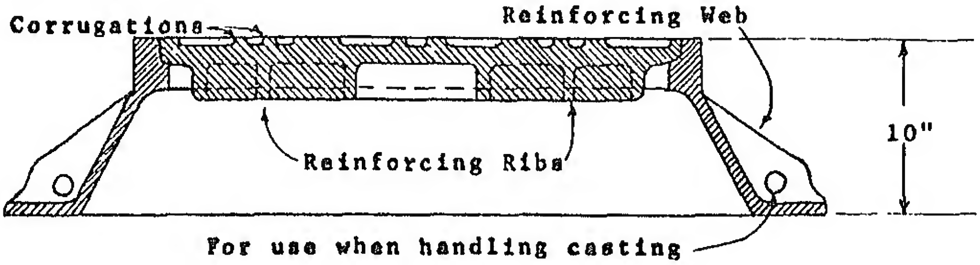


FIGURE 19

4.111 Type B frame is used in areas of street, alley, roads and highways.

Type SB Frame and Cover

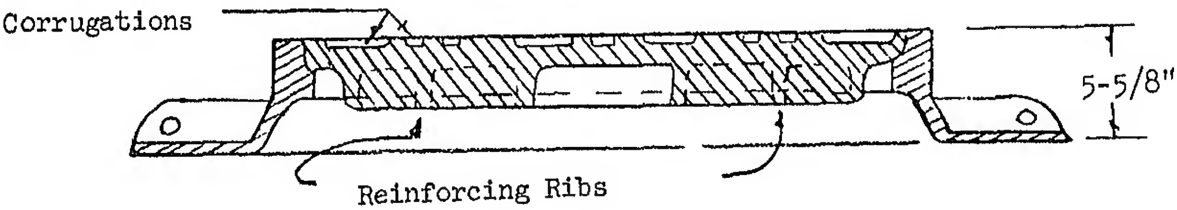


FIGURE 20

4.112 The Type SB frame is usually used in roadway regrading where advantage may be taken of shallower depths. Where the type of surfacing will permit, the SB frame may be used on new construction as an alternate to the Type B frame.

Type R Frame and Cover

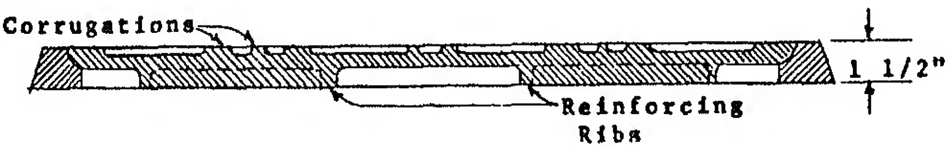


FIGURE 21

.113 The Type R frame is used in areas not subject to loads imposed by vehicular traffic such as in sidewalks, and median strips.

4.12 The manhole frame should be supported on a brick collar constructed as shown in Figure 22. The collar should be of sufficient height to bring the cover flush with the grade of the travel surface. The height of the brick collar should be at least 8 inches in highway locations, and where there is any probability that the grade will be lowered. When the manhole is located in grass plot areas, and the Type R frame is used, the manhole roof should be not less than 12 inches below the ground surface to provide sufficient cover of soil so that the sod can reestablish itself.

4.13 The solid manhole cover should be used for all manholes. The 30-inch frame with heavy duty cover should be used on all manholes for which there is heavy vehicle traffic and to provide light and ventilation within the manhole if required.

4.14 The 27-inch frame is used in general construction on all types of manholes with the exception of the 30-inch frame as stated above. The 24-inch frame is normally used on Type UM-X and UM-Y manholes.

Typical Manhole Collar

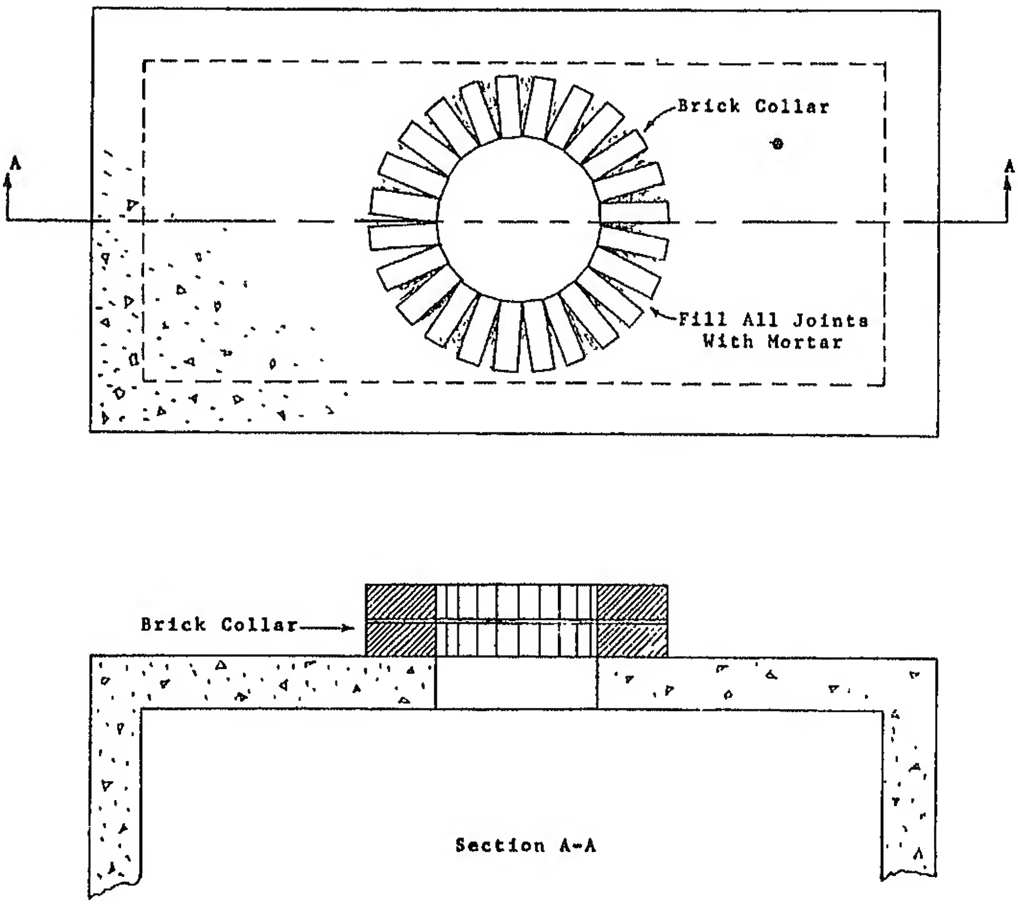


FIGURE 22

NOTES:

1. Use 2" x 4" x 8" common brick for the manhole collar.
2. Broken bricks are not to be used as a means of adjusting the frame to grade.

3. Top the upper course of bricks with a layer of mortar in which to bed the manhole frame.

4. Thoroughly fill all joints with mortar both inside and outside the collar.

5. The brick collar shall have a minimum of two courses of bricks.

4.15 Consideration should be given for utilizing light ladders for entry and exit in manholes and the placement of manhole steps should not be necessary.

4.16 In general, main conduit should enter the manhole as near as practicable equidistant between the floor and the roof and centered between the end walls. In Types UM-L, UM-J and UM-T manholes, the ducts entering the side walls should be located about 4 inches from the end wall which is farther from the central office. A minimum clearance of 12 inches should also be maintained between the main conduit formation and the roof or floor of the manhole. Unless otherwise indicated on the detailed plans, recesses should be provided at the duct entrances. Subsidiary ducts should be entered so as to provide a clearance of 4 inches from the roof and from the adjacent wall.

5. MANHOLE AND CONDUIT LOCATION

5.1 Design drawings shall be prepared by the Engineer to show specific manhole locations and the route of conduit between manholes. See Exhibit "A", "B" and "C" for typical conduit and manhole layout. In general, manholes should be located so as to avoid unnecessary hazards and also so that future work in the manhole will cause minimum interference with the normal flow of vehicular traffic. Manholes should be located outside the travelled portion of the road wherever possible. Where they must be in the travelled portion, avoid street intersection locations wherever possible. In built-up areas where the possibility of undisclosed subsurface conditions exist, test holes may be required to verify that the construction can be carried out as planned and to avoid useless excavation. The test holes should be dug one foot deeper than the depth of the proposed manhole excavation. If foreign pipes or other structures are encountered in the test holes, immediate steps should be taken to determine their ownership. If the structure cannot be removed readily, a decision must be made as to the practicability of (a) shifting the manhole, (b) arranging with the owning company for a change in the route of their plant or (c) including the structure in the manhole. The penalities or cost associated with each of these alternatives should be carefully considered before a decision is reached. Springs or underground streams will increase construction costs and should be avoided if practicable. Local, county or state ordinances will generally regulate the route location of proposed conduit systems as well as subgrade

structures. The Engineer will coordinate all proposed manhole locations and conduit routes with the appropriate public or private agencies to acquire right-of-way easement, and/or permits as required prior to actual construction. Profile drawings should not be required. In congested areas, coordination with city or county engineers and utility companies should be sufficient to locate and determine depth of subsurface structures. Refer to Paragraph 7.26 for grading requirements of conduit.

6. LENGTH OF CONDUIT SECTIONS

6.1 The length of the conduit section, manhole to manhole, manhole to termination or termination to termination, will depend on the size (diameter) and type of the conduits and cables to be installed. Conduit sections between manholes should be as long as practicable to reduce the number of manholes, splices and setups for pulling-in cable, but not of such length as to cause damage to the cable in pulling it into a duct.

6.2 The maximum conduit section should be not normally greater than 1500 feet. Lengths of 600 to 1000 feet are typical. Achieving this distance may be restricted by junction points, loading points, offsets and the amount of curvature in the conduit line between manholes. An offset is a change in plane of one portion of a straight conduit line relative to the remainder of the line. If an offset is not over about 5 feet and the radii of curvature used in offsetting are as large as 100 feet, an offset should not reduce the permitted section length.

6.3 Bends, twists or curvature in a conduit line can be made to change the general direction of the line as at street corners or curves or to avoid underground obstructions. With 1,000 feet as the length for a straight run, it is necessary to shorten the run between manholes if it has a turn. The amount of the shortening will depend on the radius of the turn and the angle of the change in direction of the line. Instructions are furnished by the conduit manufacturers or suppliers for the minimum standards as applicable for the type of conduit to be employed.

6.4 The conduit length limitations given in Paragraph 6.3 take into consideration the problem of duct rodding. A 15-foot radius, 90-degree turn is the minimum permissible for rodding with 3-foot, 4 pound quick coupling duct rods because of their weight and the friction created in pushing them through a duct.

7. EXCAVATING AND GRADING

7.1 Excavating (Manholes)

7.11 The length and width of the excavation for concrete manholes should be such that the manhole can be constructed with the interior dimensions as specified on the detailed plans and with walls of the necessary thickness at the point of minimum dimension. Where

sheeting is required to prevent caving, the excavation should be enlarged accordingly to account for the sheeting. Table 7 may be used for determining the minimum length and width of the excavation.

TABLE 7

Length and Width of Excavation

(a) Concrete manhole without sheeting (use Figure in table)

(b) Concrete manhole with 2" sheeting (add 4" to Figure in table)

Length or Width of inside of Manhole	Thickness of Manhole Wall in Inches							
	6		7		8		9	
	Length or Width or Excavation							
	ft.	in.	ft.	in.	ft.	in.	ft.	in.
3'-6"	4	6	4	8	4	10	5	0
4'-0"	5	0	5	2	5	4	5	6
4'-6"	5	6	5	8	5	10	6	0
5'-0"	6	0	6	2	6	4	6	6
5'-6"	6	6	6	8	6	10	7	0
6'-0"	7	0	7	2	7	4	7	6
6'-6"	7	6	7	8	7	10	8	0
7'-0"	8	0	8	2	8	4	8	6
7'-6"	8	6	8	8	8	10	9	0
8'-0"	9	0	9	2	9	4	9	6
8'-6"	9	6	9	8	9	10	10	0

7.12 Depth of Excavation - The depth of the excavation for manholes should be sufficient to allow a floor of the required thickness to be placed and still provide the necessary headroom, etc. The following measurements should be totaled to determine the depth of the excavation:

(a) Depth of manhole frame
(b) Depth of brick collar for manhole frame
(c) Thickness of roof
(d) Headroom of manhole
(e) Thickness of floor
(f) Plus 4 inches for layer of crushed stone if necessary to provide drainage during construction in wet locations.

Table 8 may be used for determining the minimum depth of excavation for most manholes.

TABLE 8

Depth of Excavation
for Manholes
Normal Construction-4" Collar

If the combined thickness of the roof and floor is	Add this dimension to the headroom of the manhole to obtain the required depth of the excavation		
	Type of Frame		
	B	SB	R
10"	2'-0"	1'-8"	1'-4"
11"	2'-1"	1'-9"	1'-5"
12"	2'-2"	1'-10"	1'-6"
13"	2'-3"	1'-11"	1'-7"
14"	2'-4"	2'-0"	1'-8"
15"	2'-5"	2'-1"	1'-9"

The following adjustments may be necessary:

(a) If layer of crushed stone is required for drainage - add 4 inches.
(b) If future grading operations will require lowering of the frame - add the amount that frame will be lowered.
(c) If Type R cover is used and manhole is located in a grassplot- add 6 inches.

7.13 Sheeting and Bracing - The type and amount of sheeting and bracing required for manhole excavation varies according to the stability of the soil and to the depth of the excavation. Table 9 suggests the minimum size and spacing for sheeting and bracing for various depths of excavation:

TABLE 9

Suggested Manhole Bracing and Sheeting Design

Excavation Depth in Feet	Sheet Piling		Stringers		Cross Bracing	
	Size in inches	Horizontal Spacing in Feet	Size in inches	Horizontal Spacing in Feet	Size in inches	Horizontal Spacing in Feet
		Solid and Hard Soil				
5 to 10	2x6	6	4x6	4	4x6	6
0 to 20	2x6	Tight	6x6	4	6x6	6
		Soil likely to crack or crumble				
5 to 10	2x6	3	4x6	4	4x6	6
0 to 20	2x6	Tight	6x6	4	6x6	6
		Soft sand or loose soil				
5 to 10	2x6	Tight	6x6	4	6x6	6
0 to 20	2x6	Tight	8x8	4	6x6	6

7.2 Excavating (Conduit)

7.21 For conduit trench excavations in firm soil, it is suggested that shoring material should be a minimum of 2-inch by 6-inch planks or heavier. Planking should be spaced vertically along both sides of the trench and braced with either jacks or 2 by 6-inch braces cleated or rigidly wedged.

7.22 For trenches in filled-in, soft or sandy soil which may cave in, the support structures should be placed as in Table 10 and for any soils likely to crack or crumble as in Tables 11 and 12.

TABLE 10

Suggested Bracing and Sheet Piling for All Trench Widths Soft, Sandy, Filled-In Loose Soil

Depth of Trench in Feet	Sheet Piling		Stringers		Cross Bracing	
	Size in inches	Horizontal Spacing in Feet	Size in inches	Horizontal Spacing in Feet	Size in inches	Horizontal Spacing in Feet
5 to 10	2x6	Tight	6x6	4	6x6	6
10 to 20	2x6	Tight	8x8	4	6x6	6

TABLE 11

Suggested Bracing and Sheet Piling for Trenches 4 ft. and Less in Width - Soils Likely to Crack or Crumble

Depth Trench in Feet	Sheet Piling		Stringers		Cross Bracing	
	Size in inches	Horizontal Spacing in Feet	Size in inches	Horizontal Spacing in Feet	Size in inches	Horizontal Spacing in Feet
5 to 10	2x6	3	4x6	5	4x6	5
10 to 15	2x6	2	4x6	4	4x6	4

TABLE 12

Suggested Bracing and Sheet Piling for Trenches Greater Than 4 ft. in Width - Soils Likely to Crack or Crumble

Depth of Trench in Feet	Sheet Piling		Stringers		Cross Bracing	
	Size in inches	Horizontal Spacing in Feet	Size in inches	Vertical Spacing in Feet	Size in inches	Horizontal Spacing in Feet
5 to 10	2x6	3	4x6	4	4x6	6
10 to 20	2x6	Tight	6x6	4	6x6	6

7.221 When excessive water is present, consider the use of tongue and groove sheeting to reduce pumping requirements.

7.222 When removing bracing, remove the lower braces first, leaving the upper ones until last for protection.

7.23 When foreign structures are encountered in the trench, it may be necessary to go to a greater depth than would otherwise be required in order to obtain suitable clearance for the conduit. Where this is impracticable or undesirable, the foreign structure may be moved or the trench line shifted to obtain the required clearance. If a foreign structure must be moved to obtain clearance, coordinate with the owning company to have the work done.

7.231 It is preferable to cross under gas, steam or water mains rather than above them provided, however, that the depth of the trench would not be excessively increased. A paralleling position either above or below gas, steam or water mains should be avoided, as far as practicable.

7.232 Gas and oil mains should be given special attention and precaution should be taken to guard against the fire hazards they present. Excavations in public streets should always be checked for gas leakage, even though gas mains or sewers are not directly encountered. No open flame of any sort should be permitted around excavations when the odor of gas is detected. Workmen should not be allowed to smoke and precautions should be taken to prevent pedestrians from throwing lighted cigars, cigarettes or burning matches into such excavations. It is advisable to notify the owning company when excavation involving such structures is undertaken so that a representative may be present if desired.

7.233 The minimum desirable separations between foreign structures and telephone conduit are as follows:

7.234 Electric Light or Power Conduits - Separations should be as noted by the National Electrical Safety Code, latest edition.

7.235 Other Foreign Pipes such as Gas, Water, Oil Mains, Etc. - Separations of 6 inches when crossing and 12 inches when paralleling, as measured from the nearest part of the conduit structure.

7.236 Foreign pipes which cross the trench diagonally should be supported when necessary. Foreign pipes which parallel the trench and either extend partially into the trench or are located within 12 inches of the trench should be braced laterally by shoring, except when the necessity for sheeting to support the trench walls furnishes adequate bracing for the pipe.

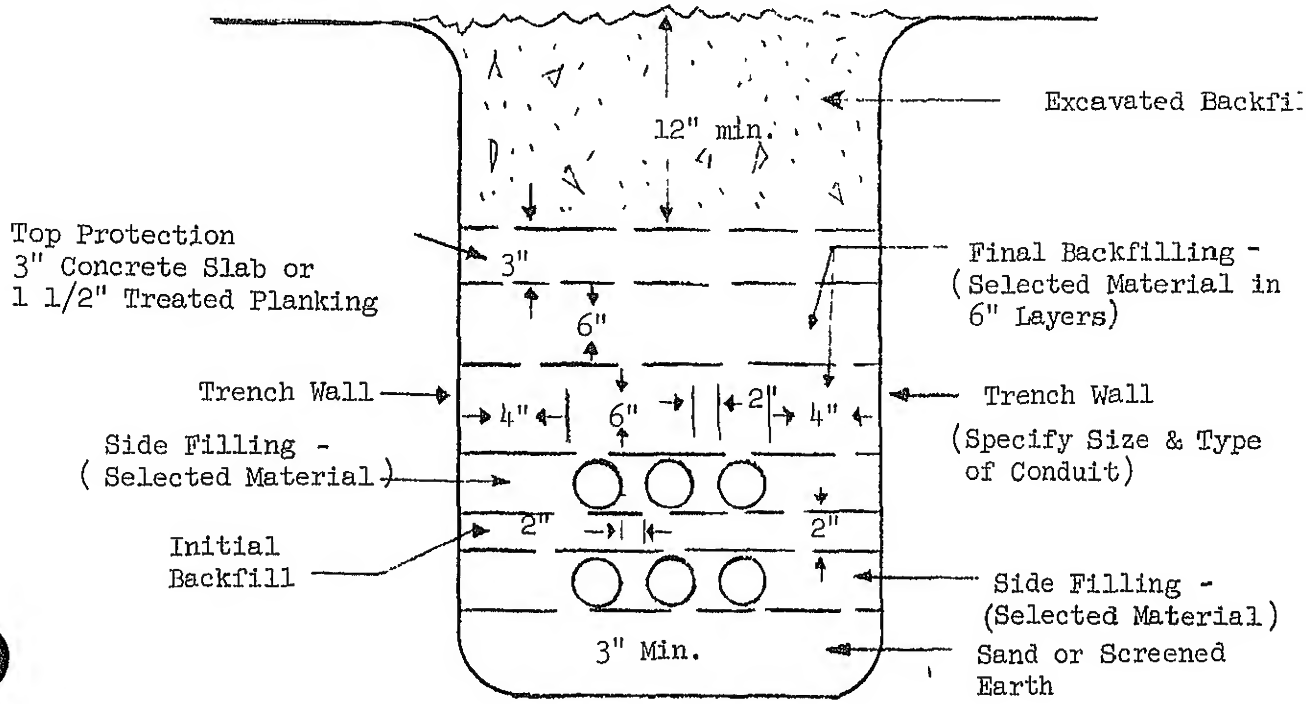
7.24 In preparing the trench bed for the conduit installation, level the trench bed to form an even base. In some cases, it may be necessary to provide sand or screened earth to provide a stable bearing. Ordinarily, no concrete base for the conduit is required. If, upon excavation, the trench bed appears to be incapable of affording firm support for the conduit, the Engineer will determine what type of base is required. If the volume of water in the trench is too great to permit the conduit to be laid or joined properly, the water can be disposed of by placing a layer of crushed stone in the trench bed through which the water can drain to a sump while the conduit is being placed. A layer of earth or sand over the stone is required prior to laying of the conduit. Where conditions are so severe that the water cannot be handled, it may be necessary to employ a system of well-points paralleling the trench to lower the ground water level to a point below the bottom of the excavation.

7.25 Conduit entrances of the conduit run at opposite ends of a manhole should be at the same level and in the same position with respect to the side walls to facilitate duct rodding, cable placing and splicing. The trench should be graded to the duct entrance of the manhole. The positions at which the trench grade to the manhole entrances should begin will change with the various conduit formations, and will vary if mitered conduit is used or if splaying is employed.

7.26 In areas where subfreezing ground conditions are expected to penetrate to the depth at which conduits will be installed, grading of the conduit runs is necessary. In such cases the grade of the trench should provide a fall of 3 inches in 100 feet for the conduit toward the lower manhole or from a high point in the conduit section toward both manholes.

FIGURE 23

Typical Conduit Placement With
Concrete Top Protection



8. CONDUIT LAYING

8.1 Detailed installation practices are furnished by the conduit manufacturers for the laying and jointing of conduit with associated fittings for bends, sweeps, bell ends, adapters for joining other types of conduits, and terminations. These installation practices are in sufficient detail to preclude a detailed description of the various types of conduit and the installation practices herein. However, the Engineer will evaluate the various types of conduit for the usage thereof based on design application and limitations, weight, costs, both for material and freight, and the installation manpower skills required.

9. BACKFILLING

9.1 Backfilling next to the conduit(s) should be free from stones or other material which might injure the conduits or conduit joints. Large boulders should not be included in any part of the backfill. In tamping the backfill at the sides of the conduit, extreme care should be exercised not to damage the joints or shift the conduit structure. Backfilling and tamping alongside the conduit should be done in layers

only an inch or two in thickness until the level of the top of the conduit is reached. Backfilling around conduit joined with mortar bandages can proceed as soon as the joints are completed. Troweled joints should be allowed to set at least 24 hours before backfilling. Concrete top protection or encasement can be backfilled as soon as completed.

9.2 Above the conduit tamp all backfill thoroughly in 6-inch layers. In most cases mechanically tamped backfill will provide a better job than hand-tamped backfill. Where a large amount of backfilling and tamping is to be done, a backfilling and tamping machine may be used to advantage. To avoid damage to conduit, do not use mechanical tampers until the conduit structure has been covered with at least 12 inches of hand-tamped backfill. In sandy soils the use of water may provide a satisfactory compaction when the backfill is placed in 6-inch layers and flooded. Cinder fill should not be permitted around conduit containing lead-sheath cables due to harmful results of galvanic action to cables. Where cinders form a part of the soil, use clean earth for the backfill adjacent to the conduits and do not replace soil containing cinders until the conduits have been covered with at least 6 inches of cinder-free soil. In cases where the soil is composed mainly of cinders, it may be advisable to encase the conduit in concrete.

9.3 Following the backfill placement but prior to any replacement of grass, sod or repaving, a test mandrel 1/4" smaller in diameter than the inside diameter of the conduit should be pulled through all one duct conduit and through two diagonally opposite ducts in multiduct conduit formations to ensure proper alignment. In addition, all conduits should be cleaned of loose materials such as concrete, mud, dirt, stones, etc. The ends of the conduit should be sealed to prevent the entrance of foreign matter and to protect against water or gas entering manhole or buildings. The seal should be made using rubber conduit plugs or "water-plug". "Plastic Duct Seal" or equivalent should not be used for conduits containing polyethylene-sheathed cable. All ducts entering central offices or other buildings should be kept plugged at all times except when necessary to open for cable placing. If the work extends over several days, the conduits should be plugged at night temporarily but replaced permanently upon completion of the work. Conduit plugs are available in two types, solid and split. The solid type is made for both square and round conduits. The split rubber plug is used to plug conduits that have cable. "Water-plug" can be applied to vacant or occupied conduits by fingers or putty knife.

9.4 Paving and sometimes temporary paving requirements are usually regulated by local, county and/or state regulations. The Engineer should coordinate the action required and make a part of the installation drawings and specifications that information as necessary in accordance with the REA Construction Contract Form 511.

9.5 All surplus excavated matter in conjunction with the backfilling operation should be removed so as not to obstruct traffic. Where space is restricted, it may be advisable to estimate the amount of surplus earth and remove this material from the job at the time it is excavated. If possible, small amounts of excavated material should be left on the job site to be used later for filling in the temporarily repaved trench where settlement has taken place.

9.6 On private property and public parks where sod or top soil has been removed, finish off the surface of the trench with top soil or sod as removed. This work should be done to the satisfaction of the property owner or authorities.

9.7 When the job is finished, all surplus material and debris should be cleared from the job site.

10. CONDUIT COVERAGE AND PROTECTION

10.1 Except as otherwise required by public authority, the depth of the trench should be sufficient to obtain at least 24 inch cover over the conduit formation including top protection if employed.

10.2 Protection for conduit can be treated wood plank or concrete placed to give mechanical protection against damage from other digging operations. Such protection may be required underneath, on top, or complete encasement. Where no hazard is considered likely, no protection is required.

10.3 Top protection should be provided where the conduit is to be placed under a roadway which may be paved at a later date. A concrete base should be provided in swampy ground where the conduit may be undermined. Submarine cable landings generally require complete concrete encasement. Protection of conduit under railroad tracks is to be as specified by the regulations of the particular railroad.

11. SUBSIDIARY CONDUIT

11.1 The term "subsidiary conduit" is commonly used to define any conduit branching off from the main conduit run. The construction and installation practices as defined for main line conduit (manhole to manhole) also apply to subsidiary conduit (manhole to manhole). The installation of subsidiary conduit or sometimes referred to as riser conduit is as follows:

11.11 The usual method of terminating a subsidiary or riser conduit at a pole is through cast iron bends which extend the underground conduit up to the pole. A coupling provides the means for jointing the bends and conduit. The upper end of the bend is attached to the pole by a pipe strap held by drive screws. It is preferable to

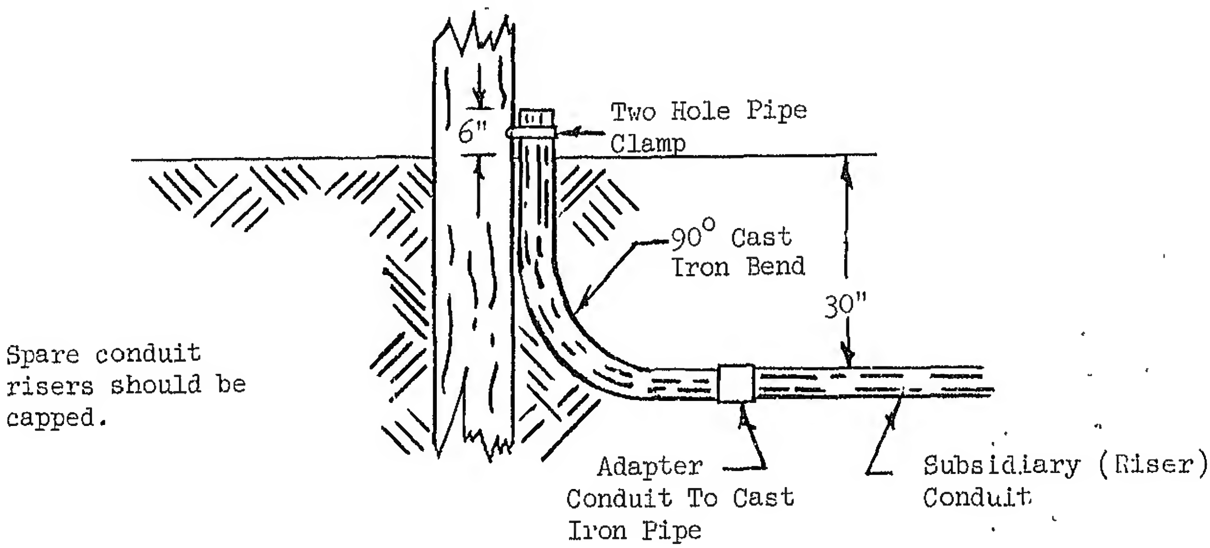
have the conduit rise on the field side of a pole leaving the road side for power cables and to avoid possible damage from vehicular traffic when poles are at the curb. Cable extending up a pole should be covered by a standard galvanized steel cable "U" guard.

NOTE: Conduit with less than 24 inch ground cover must be concrete encased. Cast iron bends need not be encased in concrete.

11.12 Subsidiary conduit entering buildings should be arranged for before the building is erected if possible. In this case suitable sleeves or stub outs can be inserted in the building wall or floor at the time of construction. If placed later, the entrance should be broken through the building wall or floor at some point not vital to the support of the building.

FIGURE 24

Typical Conduit To Pole Termination



12. CONCRETE AND AGGREGATE

12.01 The use to be made of the concrete and the conditions under which it is employed in underground conduit and manhole construction impose varying requirements on the concrete provided. All cement used in underground construction should be portland cement and conform to the specification for portland cement of the American Society for Testing Materials.

12.02 Basically there are three different types of portland cement which may be used for underground construction. These types are normal cement, high early strength cement and sulfate-resisting cement.

12.021 Normal Cement - This type should be used for all concrete construction unless otherwise indicated on the detailed plans by the Engineer. There are eight classes of concrete which should be used for the purposes as indicated below:

12.0211 Class 1A - For manholes where the concrete is to be compacted by hand tamping.

12.0212 Class 1B - For manholes where the concrete is to be compacted by mechanical vibration and also for replacing concrete pavement. It may also be used for floors in manholes where compacting is to be done by hand tamping.

12.0213 Class 1C - For manholes where the concrete is to be compacted by hand tamping and where high early strength is required. Its use may also be indicated during low temperatures.

12.0214 Class 1D - For manholes where the concrete is to be compacted by mechanical vibration and where high early strength is required, and also for concrete pavement replacement where high early strength is required. It may be used for floors in manholes where high early strength is required and where compacting is to be done by hand tamping.

12.0215 Class 2A - For conduit base or top protection and for complete encasement of multiple clay conduit.

12.0216 Class 2B - For conduit encasement, particularly where it is necessary to work the concrete between and around closely spaced units of various types of single conduit.

12.0217 Class 2C - For replacement of concrete base for asphalt, brick, granite and wood block pavement.

12.0218 Class 2D - To be used as a substitute for Class 2C concrete where high early strength is required or during low temperatures.

12.022 High Early Strength Cement - The use of high early strength cement should be used when it is necessary to remove forms and open the structure to traffic at an early date after concrete has been placed. Its use may also be indicated for construction work during low temperatures, and for use in the mortar for mortar bandage joints to improve the workability of the mix and the bonding characteristics of the bandage.

12.023 Sulfate-Resisting Cement has the characteristics to withstand exposure to severe alkali conditions. Its use should be indicated by the Engineer only under special conditions. Its setting characteristics are the same as for normal cement.

12.03 Cement should be kept dry at all times prior to use in order to prevent deterioration. It should be stored in a building or on a platform raised off the ground and covered.

12.04 No cement should be used which contains lumps that will not pulverize readily in the hand. The presence of such lumps indicates that the cement has absorbed moisture and has consequently deteriorated.

12.05 All concrete of the Class 1 grades should have a minimum compressive strength of 3600 pounds per square inch at 28 days when made with normal or sulfate-resisting cement and at 7 days when made with high early strength cement.

12.06 All concrete of the Class 2 grades should have a minimum compressive strength of 2500 pounds per square inch at 28 days when made with normal or sulfate-resisting cement and at 7 days when made with high early strength cement. The water contained in the aggregate should be considered as a part of the mixing water. Therefore, the quantity of water added at the mixer should be adjusted so that the total available water in the concrete will not exceed the quantities specified in Table 13.

12.07 Watertight Concrete - The requirement for watertight concrete is the use of durable aggregates which are completely coated with cement paste that resists the passage of water. Leakage through concrete usually is through the paste, and it can be prevented by having a sufficient quantity of watertight paste to coat all particles of aggregate and to fill all voids between them. The Class 1 concretes described have water-cement ratios that will produce watertight concrete. To ensure that concrete will be watertight, water must be prevented from flowing through or over the freshly placed concrete and washing away the cement paste. Admixtures shall not be used for the purpose of producing watertight concrete.

12.08 The aggregates used in the preparation of concrete and mortar have an important bearing on the quality of the resultant concrete products.

12.081 <u>Fine aggregate</u> should consist of natural sand, or sand prepared from stone, blast-furnace slag or gravel. Fine aggregate for concrete should be well graded from coarse to fine and, when tested by means of sieves, should conform to the requirements of Table 14.

TABLE 13

Suggested Trial Mixes for Cubic Yard of Concrete

	Class of Concrete	1A	1B	1C	1D	2A	2B	2C	2D
	Type of Cement	N or S*	N or S*	HES**	HES**	N or S*	N or S*	N or S*	HES**
	Tamping Requirement	Hand	Mechanical	Hand	Mechanical	Hand	Hand	Hand	Hand
	Slump Range (inches)	4 - 6	2 - 4	4 - 6	2 - 4	1 1/2 - 3	6 - 8	2 - 4	2 - 4
With Gravel	Cement (sacks)	6 1/2	6 1/4	6 1/2	6 1/4	4 3/4	5 1/2	4 1/2	4 1/2
	Water (gallons)	30 1/2	28 1/2	30 1/2	28 1/2	26 1/2	32	25 3/4	25 3/4
	Sand (pounds) Fine aggregate	1420	1440	1420	1440	1510	1440	1290	1290
	Sand (cubic yards) Fine aggregate	.59	.60	.59	.60	.63	.60	.54	.54
	Gravel (pounds) Coarse aggregate	1750	1780	1750	1780	1860	1770	2130	2130
	Gravel (cubic yards) Coarse aggregate	.65	.67	.65	.67	.70	.66	.80	.80
With Stone	Cement (sacks)	7	6 3/4	7	6 3/4	5 1/4	6	5	5
	Water (gallons)	33 1/4	31	33 1/4	31	29 1/2	35	28	28
	Sand (pounds) Fine aggregate	1510	1570	1510	1570	1620	1540	1420	1420
	Sand (cubic yards) Fine aggregate	.63	.65	.63	.65	.68	.64	.59	.59
	Stone (pounds) Coarse aggregate	1530	1560	1530	1560	1640	1560	1910	1910
	Stone (cubic yards) Coarse aggregate	.57	.58	.57	.58	.61	.58	.71	.71

*N - Normal S - Sulfate-resisting
**HES - High Early Strength

Fine Aggregate

	Percent By Weight
Passing a 3/8 in. sieve	100
Passing a No. 4 sieve	95 to 100
Passing a No. 16 sieve	45 to 80
Passing a No. 50 sieve	5 to 30
Passing a No. 100 sieve	0 to 8

Fine aggregate for mortar bandage joints should be well graded plaster sand containing no particles which will not pass a No. 8 sieve.

12.082 Coarse aggregate should consist of crushed stone, gravel, blast-furnace slag, or other approved inert materials of similar characteristics, or combinations thereof, having hard, strong, durable pieces, free from adherent coatings and conforming to the requirements of the specification of the American Society for Testing and Materials.* In coarse aggregate, the amount of foreign substances such as soft fragments, coal, clay, shale and other materials detrimental to the quality of concrete should not exceed 5 percent of the total weight of the coarse aggregate. Coarse aggregate for concrete should conform to the requirements of Table 15.

TABLE 15

Intended Use	Class of Concrete	Min. Sieve Size	Max. Size
Conduit Protection	2A	No. 4	3/4 in.
Conduit Encasement	2B	No. 4	1/2 in.
Pavement Replacement	2C, 2D	No. 4	1 1/2 in.

In no case should cinders be used to form a part of the aggregate for concrete to be used in underground conduit or manhole construction work.

12.09 Aggregates should be stored in such a manner as to prevent mixture with other aggregates until they are used and also to prevent the inclusion of foreign materials.

12.10 Concrete construction during cold weather may be carried on satisfactorily provided suitable precautions are observed. In early winter, when freezing temperatures occur only at night, it is necessary to protect concrete from freezing after it is placed. As the weather grows colder and freezing temperatures prevail, it may be necessary to heat the mixing water and aggregates in addition to protecting the concrete after it is placed. With the approval of the Engineer, concrete

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pecification C33-67 of the American Society for Testing

substituted for normal cement. The earth surrounding the conduit installation also serves to protect the concrete from freezing. Immediately after a conduit installation in cold weather, the trench should be backfilled with material that is not in a frozen state.

12.11 If concrete has been damaged by freezing, the frozen concrete should be removed and replaced with freshly mixed concrete.

12.12 In localities where ready-mixed concrete is available, the use of this material should be considered as it affords convenience of delivery and uniformity of quality at a reasonable cost.

12.13 Concrete Encasement - In general the following conditions should require the conduit to be concrete encased:

12.131 30 inches or less of earth cover in road or street crossings.

12.132 At all railway crossings.

12.133 Less than 30 inches of cover in parallel to and within street, highway or road travel areas.

12.134 In areas of stream crossings and storm water canals or ditches.

12.135 Radius bends of 20° or more in conduit lengths of 550 feet or longer.

13. SPECIAL CONSIDERATION

13.1 Detailed drawings and specific instructions shall accompany conduit plans involving departures from usual construction practices.

13.2 The procedures outlined in the following paragraphs are in accordance with general accepted practices prescribed for the construction of communication lines crossing the tracks of railroads, excepting street railways. Where any requirements do not meet railroad, municipal or state requirements such railroad, municipal, or state requirements shall govern.

13.21 The work should be done at such a time and in such a manner as not to interfere with the proper and safe use or operation of the property and tracks of the railroad company, previous arrangements

having been made with the duly authorized representative of the railroad company for date and time of commencement.

13.22 The underground system on the railroad property should be located as to be subject to the least practicable disturbance. Care should be exercised to avoid catch basins, pipes or underground structures which have been installed or are planned for the future. Manholes should, where practicable, be located off the railroad right-of-way.

13.23 The top of all conduit protection within the roadbed section (within the limits of 6 feet beyond each outside rail) should generally be located at a depth of not less than 42 inches below the base of the rail. Arrangements may sometimes be made with the railroad company, whereby this clearance may be reduced. In no case, however, should the top of the conduit protection extend within 12 inches of the bottom of the ballast section which is subject to working or clearing.

13.24 In no case should the conduit structure be less than 18 inches below the surface of the ground in the portion of the right-of-way outside the roadbed section.

13.25 Where underground conduit construction terminates at terminal poles, the side clearance of such poles from the nearest track rail should be 12 feet. Where manholes which project above the surface of the ground are employed, the side clearance, unless physical conditions prevent, should be not less than 12 feet from the nearest rail, except that at sidings a clearance of 7 feet may be allowed.

13.3 Loading Manholes - The size of a loading manhole is generally determined by the maximum number of loading coil cases the manhole will contain and the number of cables for which racking space must be provided. The following considerations should be made utilizing the suggested standard manhole sizes for the installation of load coil cases prior to special design:

13.31 If the number and size of the cases are small, the cases may be placed in the manhole corners, attached to the walls, or placed across the ends of the manhole. The only requirement under these considerations is that sufficient space must remain after the cases are installed to permit normal handling and splicing of the cables.

13.32 Another method which also applies to standard manholes is to lay the cases on their sides (under the racks). This method leaves the middle of the manhole floor clear for working space.

13.4 Handholes, pull boxes and splice boxes are generally considered for special application such as within large building or industrial complexes, crossing long span bridges, etc. The usage of these special types of construction should be controlled to areas of restrictive vehicular traffic and restricted access by the general public due to the normal shallow grade of the conduits. There is no standard design for these particular facilities; consequently, the Engineer should consider safety, working room, size of cables, bending radii of cables, etc., in his design considerations.

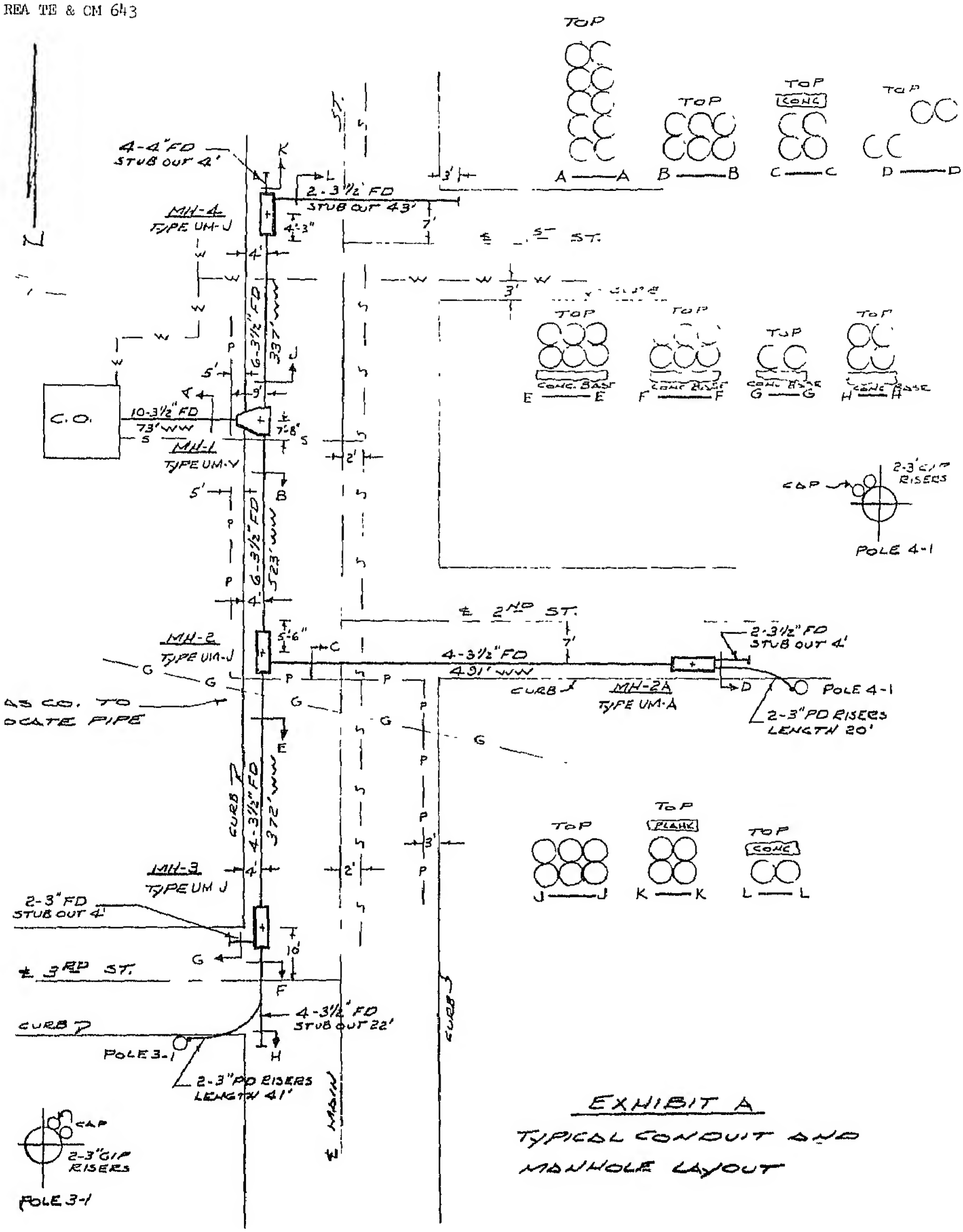
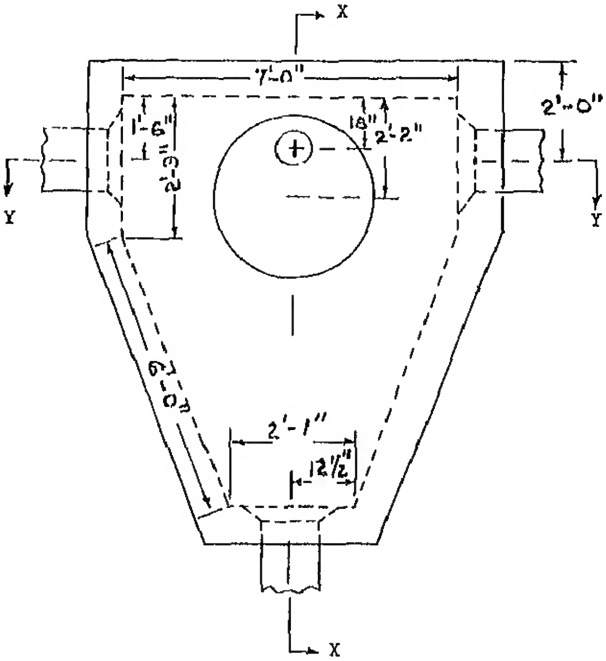


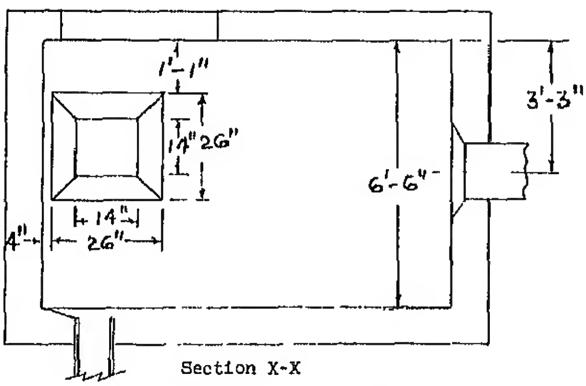
EXHIBIT A

TYPICAL CONDUIT AND MANHOLE LAYOUT

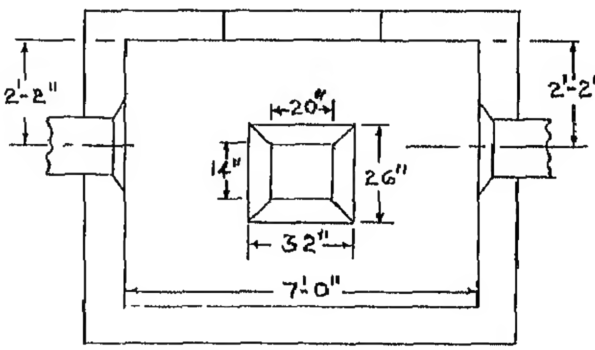
Manhole No's 1

Manhole Type UM-V





Section X-X



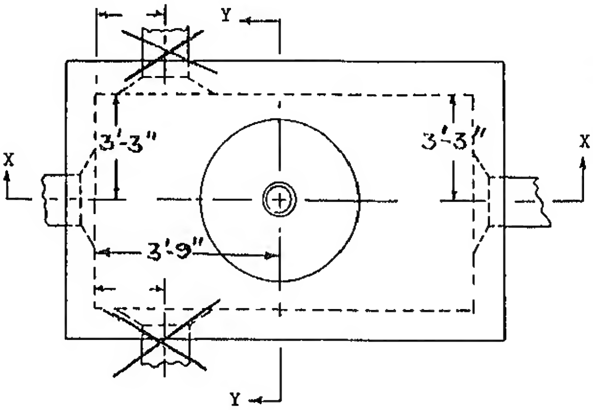
Section Y-Y

Floor			Wall				
Thickness (inches)	Reinforcing		Thickness (inches)	Vert. Reinforcing		Horiz. Reinforcing	
	Size	O.C.		Size	O.C.	Size	O.C.
6"	5/8"	8"	6	1/2"	6"	3/8"	12"

Sump or Drain	Option C	Option S ✓
Frame and Cover	Type B ✓	Type R

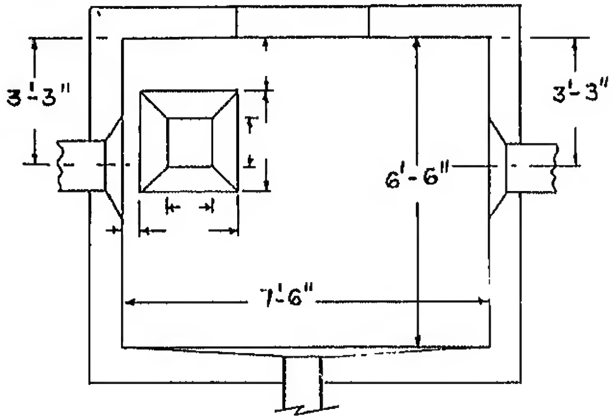
Exhibit "B"
Page 1 of 2

Typical Manhole Design Detail

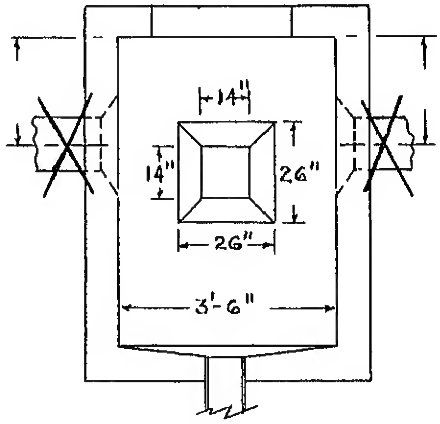


Manhole No's. 2,3,4

Manhole Type UM-A



Section X-X



Section Y-Y

Floor			Wall				
Thickness (inches)	Reinforcing Size	Reinforcing O.C.	Thickness (inches)	Vert. Reinforcing Size	Vert. Reinforcing O.C.	Horiz. Reinforcing Size	Horiz. Reinforcing O.C.
6	5/8"	8"	6	1/2"	6"	3/8"	12"

Sump or Drain	Option C	Option S ✓
Frame and Cover	Type B ✓	Type R

Exhibit "B"
Page 2 of 2

EXHIBIT C

TYPICAL ABBREVIATIONS AND SYMBOLS FOR CONDUIT AND MANHOLE SYSTEM LAYOUT

Abbreviations

ACD - Asbestos Cement Duct
BW - Building to Wall of Manhole Distance
CONC - Concrete
C.O. - Central Office
CC - Center to Center Distance Between Manholes
CIP - Cast Iron Pipe
FD - Fiber Duct
FT - Foot
HH - Handhole
HWY - Highway
IN. - Inch
I.D. - Inside Diameter
MH - Manhole
MCD - Multiple Concrete Duct
MTD - Multiple Tile Duct
MI - Mile
O.D. - Outside Diameter
PD - Plastic Duct
R/W - Right of Way
S - Steel
ST. - Street
STD - Single Tile Duct
WW - Manhole Wall to Manhole Wall Distance
℄ - Center Line of Street, Road, Alley or Highway

Symbols

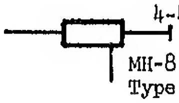
4-4"-MTD — Existing 4 way 4" multi-tile-duct

6-3 1/2" FD — Proposed 6-3 1/2" fiber duct

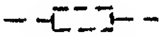
Proposed (Future) conduit

Existing Type UM-A manhole No. 3

Proposed Type UM-A manhole No. 6

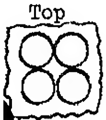


Proposed Type UM-J manhole No. 8 with 4-4" plastic duct stub-out 5'-0"



Proposed future manhole

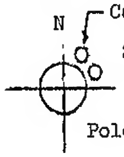
Conduit configuration (looking with back toward C.O.) showing 4-4" plastic duct-direct buried.



Conduit configuration (looking with back toward C.O.) showing 4-3 1/2" fiber duct-concrete encased

Conduit configuration (looking with back toward C.O.) showing 2-3 1/2" asbestos cement duct direct buried with a treated plank top protection.

Conduit configuratior (looking with back tc C.O.) showing 2-4" pl duct with concrete ba



Pole riser conduit (c iron pipe) terminatio showing pole quadrant

— G — G — G — Gas Line

— W — W — W — Water Line

— S — S — S — Sewer Line

— O — O — O — Oil Line

— P — P — P — Power Line

— T — T — T — Telephone Line

— X — X — X — Fence